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MARSLAND PRESS
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# A NOVEL KNEE SHAPED PATCH ANTENNA FOR MIMO COMMUNICATIONS

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**Abstract:** A compact two element MIMO (Multiple Input Multiple Output) system is proposed using a Knee shaped patch antenna giving an impedance bandwidth of 22.85 % and resonating at a frequency of 7.1 GHz. The proposed MIMO system offers improved bandwidth, return loss and good isolation characteristics. The developed system resonating at 7.1GHz frequency for VSWR≤2 can be used for 4G & WiMAX applications. The simulation results of return loss, mutual coupling and gain are presented.
[Fahd baabdullah, Adnan Affandi, & Abdullah M.Dobaie. **A NOVEL KNEE SHAPED PATCH ANTENNA FOR MIMO COMMUNICATIONS**. *Rep Opinion* 2024;16(1):15-19]. ISSN 1553-9873 (print); ISSN 2375-7205 (online). http://www.sciencepub.net/report. 03. doi:10.7537/marsroj160124.03.

**Keywords***:* Knee shaped patch antenna, MIMO systems, impedance bandwidth, mutual coupling

## 1. Introduction

In the current 3G & 4G wireless communication systems, MIMO (Multiple Input Multiple Output) technology plays vital role in giving improved data rates. The advanced wireless applications require larger data rates with high speed, quality of transmission and accuracy. The technique of improving the channel capacity with increasing the no. of antennas at the transmitter and receiver was first predicted by Foschini in [1]. This technique has motivated many researchers and academicians to explore the ways of enhancing the data rates. The primary research on MIMO technology mainly emphasizes data encoding, DSP algorithms, channel characteristics, receiver design and antenna design [2].

In MIMO systems, multiple antennas are involved at closer spacing, leading to more technical challenges as compared to a SISO (Single Input Single Output) system. Hence, the basic aim of MIMO antenna design is to minimize the correlation between the multiple signals [3]. The parameter that describes the correlation between the received signals in highly diversified environments is mutual coupling, as it may affect the performance of the system. By estimating the mutual coupling between antennas, one can analyze the electromagnetic field interactions that exist between antenna elements of a MIMO system. Higher mutual coupling usually results in higher correlation coefficients thus reducing the antenna efficiencies. The impact of mutual coupling on the capacity of MIMO systems is studied in [4].

The mutual coupling mainly depends on the distance between the elements of an antenna array. By increasing the separation between the antennas, the mutual coupling can be reduced. However, the distance between the antennas cannot be made too large, as MIMO systems have their major applications in Mobile terminals, laptops, MODEMs, WLAN Access Points etc., where size is the main concern. Not only the physical constraints but also the concerns on ergonomics and aesthetics are few other important aspects in the design of MIMO systems. The distance between antenna elements in practice cannot be extended beyond a certain level which limits the use of spatial diversity to achieve the desired spectral efficiencies and transmission qualities. Hence, always there is a need to develop antenna systems with reduced mutual coupling.

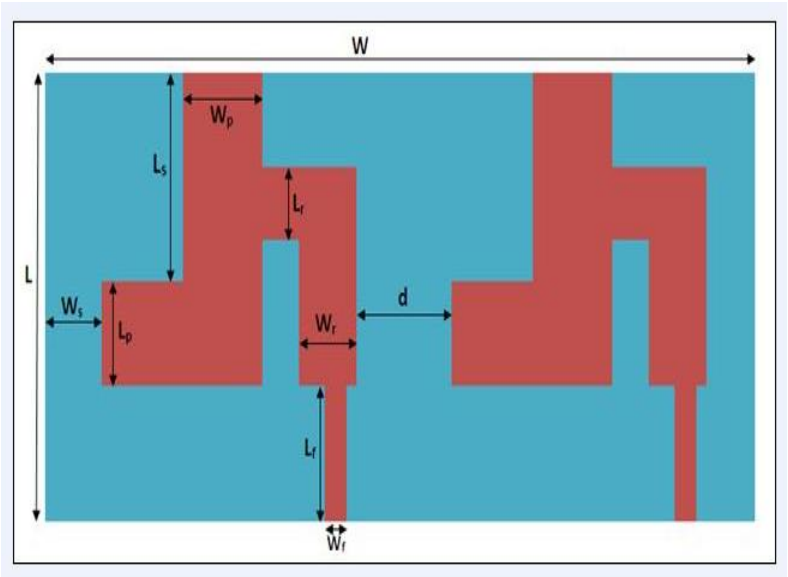
In the present research article, a novel knee shaped microstrip antenna resonating at 7.1 GHz frequency is proposed. A 2×2 MIMO system is developed using the proposed antenna and mutual coupling between the two antennas is calculated for various separations. The developed MIMO system is shown to give a reduced mutual coupling around -18 dB at the resonant frequency. In section 2, the proposed antenna geometry is presented and in Section 3 the results of the proposed antenna system are presented. The final conclusion of the paper is given in Section 4.

## 2. Antenna Design

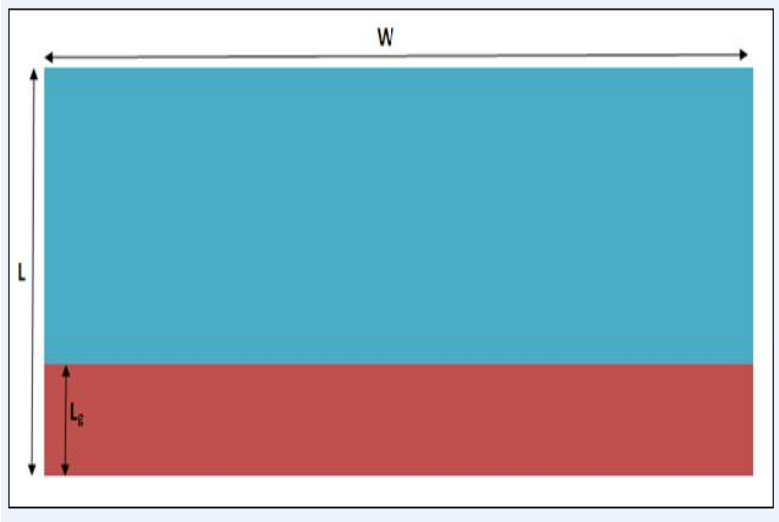
The current wireless applications require the antennas with larger bandwidths to handle higher data rates.The bandwidth of microstrip antenna can be increased using air substrate. However, dielectric substrate antennas are preferred, if compact antenna size is required . In practice, various methods are used to improve the impedance bandwidth. These include

introducing parasitic element either in coplanar or stack configuration, increasing the substrate thickness and modifying the shape of a patch by inserting slots. The last approach is particularly attractive because it can provide excellent bandwidth improvement and maintain a single-layer radiating structure to preserve the antenna's thin profile characteristic.

The proposed Knee shaped patch antenna is shown in Fig. 1. The antenna is developed on a glass epoxy substrate of size 100×45 mm2 with permittivity value εr = 4.3. The various dimensions of the antenna are shown in Table 1. A normal rectangular patch antenna gives the bandwidth only in the range of 3-5% [5]. To improve the bandwidth of the antenna, the ground plane is reduced. This is due to the fact that, when the ground plane is reduced, multiple resonant frequencies are generated and these frequencies couple each other resulting in improved impedance bandwidth [6,7]. Hence, in the present work the ground plane of the antenna is reduced to 100×13 mm2 giving an improvement in the impedance bandwidth.




(a)




(b)

Fig.1. The proposed Knee shaped patch Antenna (a) Top view (b) Reduced Ground Plane

Table 1. The dimensions of the proposed Knee shaped patch antenna

| Parameter | Dimension(mm) |
|---|---|
| W | 100 |
| L | 45 |
| Ws | 10 |
| Ls | 22 |
| Wp | 8 |
| Lp | 8 |
| $W_r$ | 8 |
| $L_r$ | 8 |
| $W_f$ | 3 |
| $L_f$ | 15 |
| $L_g$ | 13 |
| h | 1.6 |
| $\varepsilon_r$ | 4.3 |

## 3. Results

The S-parameters of the proposed antenna are shown in Fig.2. The antenna gives an impedance bandwidth of 22.85%, resonating at 7.1 GHz frequency and operating in the frequency range 6.2 GHz to 7.8 GHz. The mutual coupling (S12) of the developed MIMO system also can be seen in the Fig.2. At the resonant freqency, the mutual coupling is found as -18 dB for a separation of 20 mm between the two antennas.


Fig 2. S-Parameters of the proposed Knee shaped patch antenna

The main objective of the paper is to study the variation of mutual coupling by varying the distance between the antennas. Usually, the mutual coupling increases with the reduction of separation between the antennas and viceversa. For the propsoed Knee shaped patch antenna, the mutual coupling is studied for various separations between the antennas as shown in Fig.3. From the figure,it can be observed that the mutual coupling at the resonant frequency is almost same irrespective of the separation between the antennas. The mutual coupling is almost same at the resonant frequency, though the distance between the antennas is varied from 12 to 20 mm. This important feature of the developed antenna is suitable for current wireless applications, where miniaturization of the MIMO system is the main criteria. The gain plot of the proposed antenna system is shown in Fig. 4. From the plot it can be observed that the antenna gives a gain of 7 dB at the resonant frequency. The radiation patterns on E plane and H plane at the resonant frequency can be seen in Fig. 5.

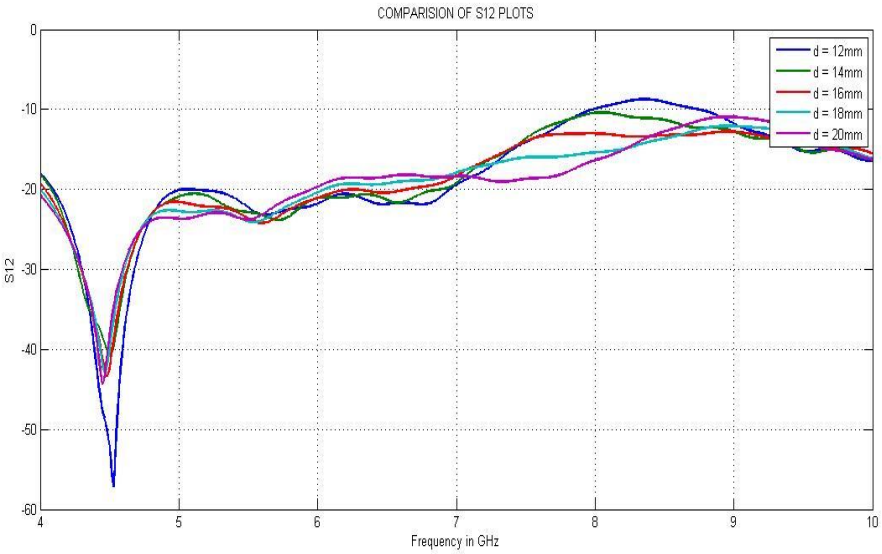



Fig 3. Study on mutual coupling between the antennas by varying the distance between two antennas

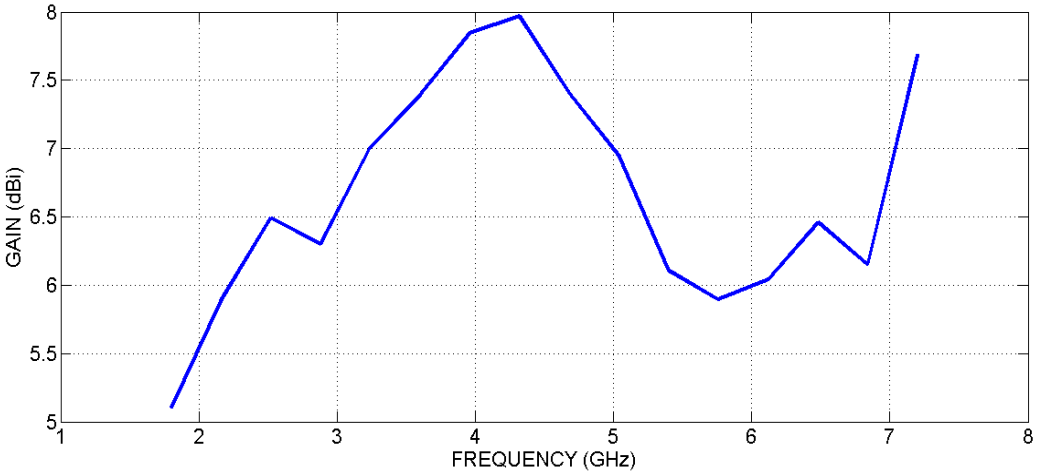
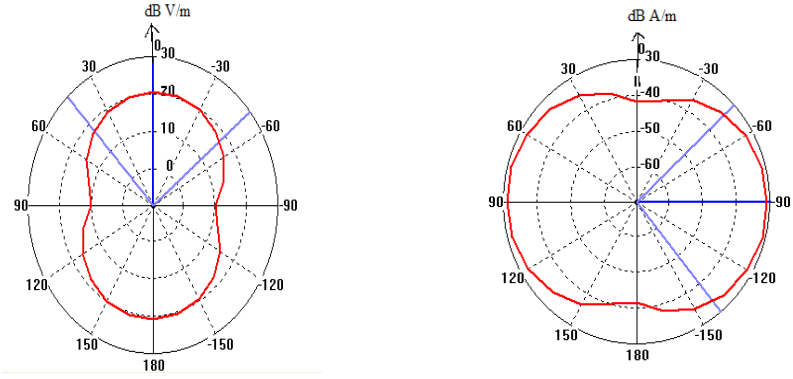



Fig. 4. Gain of the proposed antenna




(a) (b)

Fig.5. Radiation Patterns of the proposed MIMO antenna system (a) E Plane (b) H Plane

## 4. Conclusion

In this paper, a two element MIMO system is proposed using a Knee shaped patch antenna. The proposed antenna array resonates at 7.1 GHz, offering an improved bandwidth of 22.85% with return loss < -27dB and mutual coupling around -18 dB. This mutual coupling is almost same at the resonant frequency though the distance between the antennas is varied from 12 to 20 mm. These characteristics are well suited for most of the 4G MIMO applications. The proposed study can be extended by employing more no. of antennas in MIMO system for improving the channel capacity of the MIMO systems.

1/18/2024

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